



calculatoratoz.com



unitsconverters.com

Preliminary Design Formulas

Calculators!

Examples!

Conversions!

Bookmark calculatoratoz.com, unitsconverters.com

Widest Coverage of Calculators and Growing - **30,000+ Calculators!**
Calculate With a Different Unit for Each Variable - **In built Unit Conversion!**
Widest Collection of Measurements and Units - **250+ Measurements!**

Feel free to SHARE this document with your friends!

[Please leave your feedback here...](#)



List of 27 Preliminary Design Formulas

Preliminary Design

1) Crew Weight given Fuel and Empty Weight Fraction

$$\text{fx } W_c = \text{DTW} \cdot (1 - E_f - F_f) - \text{PYL}$$

[Open Calculator !\[\]\(a870788d6ed9b8fd294b7654a8c8526b_img.jpg\)](#)

$$\text{ex } 12600\text{kg} = 250000\text{kg} \cdot (1 - 0.5 - 0.4) - 12400\text{kg}$$

2) Crew Weight given Takeoff Weight

$$\text{fx } W_c = \text{DTW} - \text{PYL} - \text{FW} - \text{OEW}$$

[Open Calculator !\[\]\(c50c8b7b2cc2cf9ff925edec0ee94c0d_img.jpg\)](#)

$$\text{ex } 12600\text{kg} = 250000\text{kg} - 12400\text{kg} - 100000\text{kg} - 125000\text{kg}$$

3) Design Range given Range Increment

$$\text{fx } R_D = R_H - \Delta R$$

[Open Calculator !\[\]\(f60b7a900783ac3fd531bfd9c111be6d_img.jpg\)](#)

$$\text{ex } 52\text{km} = 123\text{km} - 71\text{km}$$

4) Empty Weight Fraction

$$\text{fx } E_f = \frac{\text{OEW}}{\text{DTW}}$$

[Open Calculator !\[\]\(83bbbd261710c59db0214aa27b2edc0d_img.jpg\)](#)

$$\text{ex } 0.5 = \frac{125000\text{kg}}{250000\text{kg}}$$



5) Empty Weight Fraction given Takeoff Weight and Fuel Fraction

$$\text{fx } E_f = 1 - F_f - \frac{\text{PYL} + W_c}{\text{DTW}}$$

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235_img.jpg\)](#)

$$\text{ex } 0.5 = 1 - 0.4 - \frac{12400\text{kg} + 12600\text{kg}}{250000\text{kg}}$$

6) Empty Weight given Empty Weight Fraction

$$\text{fx } \text{OEW} = E_f \cdot \text{DTW}$$

[Open Calculator !\[\]\(3e2231b1ad3ca8da8658228c00dd08e0_img.jpg\)](#)

$$\text{ex } 125000\text{kg} = 0.5 \cdot 250000\text{kg}$$

7) Empty Weight given Takeoff Weight

$$\text{fx } \text{OEW} = \text{DTW} - \text{FW} - \text{PYL} - W_c$$

[Open Calculator !\[\]\(0d5ec72f61334709c3fc9450209b754f_img.jpg\)](#)

$$\text{ex } 125000\text{kg} = 250000\text{kg} - 100000\text{kg} - 12400\text{kg} - 12600\text{kg}$$

8) Fuel Fraction

$$\text{fx } F_f = \frac{\text{FW}}{\text{DTW}}$$

[Open Calculator !\[\]\(b64b40baaee5acddc1eab8538ba84754_img.jpg\)](#)

$$\text{ex } 0.4 = \frac{100000\text{kg}}{250000\text{kg}}$$



9) Fuel Fraction given Takeoff Weight and Empty Weight Fraction

$$fx \quad F_f = 1 - E_f - \frac{PYL + W_c}{DTW}$$

[Open Calculator !\[\]\(e78f798d4ea5c530c9db49e7d26e6b95_img.jpg\)](#)

$$ex \quad 0.4 = 1 - 0.5 - \frac{12400kg + 12600kg}{250000kg}$$

10) Fuel Weight given Fuel Fraction

$$fx \quad FW = F_f \cdot DTW$$

[Open Calculator !\[\]\(05be7c7a8995decd503647c99211f7c2_img.jpg\)](#)

$$ex \quad 100000kg = 0.4 \cdot 250000kg$$

11) Fuel Weight given Takeoff Weight

$$fx \quad FW = DTW - OEW - PYL - W_c$$

[Open Calculator !\[\]\(fe3aebe81acea8d45108cd2768939da7_img.jpg\)](#)

$$ex \quad 100000kg = 250000kg - 125000kg - 12400kg - 12600kg$$

12) Harmonic Range given Range Increment

$$fx \quad R_H = \Delta R + R_D$$

[Open Calculator !\[\]\(899d8b7697d64725bf017d3296cfcf1b_img.jpg\)](#)

$$ex \quad 123km = 71km + 52km$$

13) Helicopter Flying Range

$$fx \quad R = 270 \cdot \frac{G_T}{W_a} \cdot \frac{C_L}{C_D} \cdot \eta_r \cdot \frac{\xi}{c}$$

[Open Calculator !\[\]\(40770d9ed6ed4f1222ebf89a1396e8b2_img.jpg\)](#)

$$ex \quad 1002.552km = 270 \cdot \frac{37.5kg}{1001N} \cdot \frac{1.1}{0.51} \cdot 3.33 \cdot \frac{2.3}{0.6kg/h/W}$$



14) Maximum Lift over Drag

$$\text{fx } LD_{\text{max_ratio}} = K_{LD} \cdot \left(\frac{AR}{\frac{S_{\text{wet}}}{S}} \right)^{0.5}$$

Open Calculator 

$$\text{ex } 19.79899 = 14 \cdot \left(\frac{4}{\frac{10.16\text{m}^2}{5.08\text{m}^2}} \right)^{0.5}$$

15) Optimum Range for Jet Aircraft in Cruising Phase

$$\text{fx } R = \frac{V_{L/D(\text{max})} \cdot LD_{\text{max_ratio}}}{c} \cdot \ln\left(\frac{W_i}{W_f}\right)$$

Open Calculator 

$$\text{ex } 1002.472\text{km} = \frac{42.9\text{kn} \cdot 19.7}{0.6\text{kg/h/W}} \cdot \ln\left(\frac{514\text{kg}}{350\text{kg}}\right)$$

16) Optimum Range for Prop-Driven Aircraft in Cruising Phase

$$\text{fx } R_{\text{opt}} = \frac{\eta \cdot LD_{\text{max_ratio}}}{c} \cdot \ln\left(\frac{W_i}{W_f}\right)$$

Open Calculator 

$$\text{ex } 42.24347\text{km} = \frac{0.93 \cdot 19.7}{0.6\text{kg/h/W}} \cdot \ln\left(\frac{514\text{kg}}{350\text{kg}}\right)$$

17) Payload Weight given Fuel and Empty Weight Fractions

$$\text{fx } \text{PYL} = \text{DTW} \cdot (1 - E_f - F_f) - W_c$$

Open Calculator 

$$\text{ex } 12400\text{kg} = 250000\text{kg} \cdot (1 - 0.5 - 0.4) - 12600\text{kg}$$



18) Payload Weight given Takeoff Weight

$$\text{fx } \text{PYL} = \text{DTW} - \text{OEW} - W_c - \text{FW}$$

[Open Calculator !\[\]\(d3fb9f94af8b26d1c844efa9a98805b0_img.jpg\)](#)

$$\text{ex } 12400\text{kg} = 250000\text{kg} - 125000\text{kg} - 12600\text{kg} - 100000\text{kg}$$

19) Preliminary Endurance for Jet Aircraft

$$\text{fx } P_E = \frac{\text{LDmax}_{\text{ratio}} \cdot \ln\left(\frac{W_i}{W_f}\right)}{c}$$

[Open Calculator !\[\]\(e1d6102fe77919492c04879c8450f1f5_img.jpg\)](#)

$$\text{ex } 45423.09\text{s} = \frac{19.7 \cdot \ln\left(\frac{514\text{kg}}{350\text{kg}}\right)}{0.6\text{kg/h/W}}$$

20) Preliminary Endurance for Prop-Driven Aircraft

$$\text{fx } E = \frac{\text{LDEmax}_{\text{ratio}} \cdot \eta \cdot \ln\left(\frac{W_{L(\text{beg})}}{W_{L(\text{end})}}\right)}{c \cdot V_{(E_{\text{max}})}}$$

[Open Calculator !\[\]\(ab4e2b3fc7e7887b7a72f548aa6f5e60_img.jpg\)](#)

$$\text{ex } 2028.252\text{s} = \frac{26 \cdot 0.93 \cdot \ln\left(\frac{400\text{kg}}{300\text{kg}}\right)}{0.6\text{kg/h/W} \cdot 40\text{kn}}$$

21) Preliminary Take Off Weight Built-up for Manned Aircraft

$$\text{fx } \text{DTW} = \text{PYL} + \text{OEW} + \text{FW} + W_c$$

[Open Calculator !\[\]\(5abce1a84a655b073239ab33e1199487_img.jpg\)](#)

$$\text{ex } 250000\text{kg} = 12400\text{kg} + 125000\text{kg} + 100000\text{kg} + 12600\text{kg}$$



22) Preliminary Take off Weight Built-Up for Manned Aircraft given Fuel and Empty Weight Fraction

$$\text{fx } DTW = \frac{PYL + W_c}{1 - F_f - E_f}$$

[Open Calculator !\[\]\(9dfdaff1d86ba3c1f8353b4d1b61b8c5_img.jpg\)](#)

$$\text{ex } 250000\text{kg} = \frac{12400\text{kg} + 12600\text{kg}}{1 - 0.4 - 0.5}$$

23) Takeoff Weight given Empty Weight Fraction

$$\text{fx } DTW = \frac{OEW}{E_f}$$

[Open Calculator !\[\]\(2b376d1a92330ab09dad2665d2f89bf5_img.jpg\)](#)

$$\text{ex } 250000\text{kg} = \frac{125000\text{kg}}{0.5}$$

24) Takeoff Weight given Fuel Fraction

$$\text{fx } DTW = \frac{FW}{F_f}$$

[Open Calculator !\[\]\(c444627dab9fee9a1550c053ffaaaae2_img.jpg\)](#)

$$\text{ex } 250000\text{kg} = \frac{100000\text{kg}}{0.4}$$



25) Velocity at Maximum Endurance given Preliminary Endurance for Prop-Driven Aircraft

$$\text{fx } V_{(E_{\max})} = \frac{LD E_{\max \text{ratio}} \cdot \eta \cdot \ln\left(\frac{W_{L(\text{beg})}}{W_{L(\text{end})}}\right)}{c \cdot E}$$

[Open Calculator !\[\]\(6605b201d6f14d9b3bcb8ab5f274d107_img.jpg\)](#)

$$\text{ex } 40.00497 \text{kn} = \frac{26 \cdot 0.93 \cdot \ln\left(\frac{400 \text{kg}}{300 \text{kg}}\right)}{0.6 \text{kg/h/W} \cdot 2028 \text{s}}$$

26) Velocity for Maximizing Range given Range for Jet Aircraft

$$\text{fx } V_{L/D(\max)} = \frac{R \cdot c}{LD_{\max \text{ratio}} \cdot \ln\left(\frac{W_i}{W_f}\right)}$$

[Open Calculator !\[\]\(e8fb589d58dad1692debababa5e928b6_img.jpg\)](#)

$$\text{ex } 42.79419 \text{kn} = \frac{1000 \text{km} \cdot 0.6 \text{kg/h/W}}{19.7 \cdot \ln\left(\frac{514 \text{kg}}{350 \text{kg}}\right)}$$

27) Winglet Friction Coefficient

$$\text{fx } \mu_{\text{friction}} = \frac{4.55}{\log_{10}(\text{Re}_{\text{wl}}^{2.58})}$$

[Open Calculator !\[\]\(4688aadfd656ded00cd6bdfae55089a9_img.jpg\)](#)

$$\text{ex } 0.476772 = \frac{4.55}{\log_{10}((5000)^{2.58})}$$



Variables Used

- **AR** Aspect Ratio of a Wing
- **c** Power Specific Fuel Consumption (*Kilogram per Hour per Watt*)
- **C_D** Drag Coefficient
- **C_L** Lift Coefficient
- **DTW** Desired Takeoff Weight (*Kilogram*)
- **E** Endurance of Aircraft (*Second*)
- **E_f** Empty Weight Fraction
- **F_f** Fuel Fraction
- **FW** Fuel Weight to be Carried (*Kilogram*)
- **G_T** Weight of Fuel (*Kilogram*)
- **K_{LD}** Landing Mass Fraction
- **LDE_{max}_{ratio}** Lift to Drag Ratio at Maximum Endurance
- **LD_{max}_{ratio}** Maximum Lift-to-Drag Ratio of Aircraft
- **OEW** Operating Empty Weight (*Kilogram*)
- **P_E** Preliminary Endurance of Aircraft (*Second*)
- **PYL** Payload Carried (*Kilogram*)
- **R** Range of Aircraft (*Kilometer*)
- **R_D** Design Range (*Kilometer*)
- **R_H** Harmonic Range (*Kilometer*)
- **R_{opt}** Optimum Range of Aircraft (*Kilometer*)
- **Re_{wl}** Winglet Reynolds Number
- **S** Reference Area (*Square Meter*)



- S_{wet} Aircraft Wetted Area (Square Meter)
- $V_{(\text{Emax})}$ Velocity for Maximum Endurance (Knot)
- $V_{\text{L/D(max)}}$ Velocity at Maximum Lift to Drag Ratio (Knot)
- W_a Aircraft Weight (Newton)
- W_c Crew Weight (Kilogram)
- W_f Weight of Aircraft at End of Cruise Phase (Kilogram)
- W_i Weight of Aircraft at Beginning of Cruise Phase (Kilogram)
- $W_{\text{L(beg)}}$ Weight of Aircraft at Beginning of Loiter Phase (Kilogram)
- $W_{\text{L,end}}$ Weight of Aircraft at End of Loiter Phase (Kilogram)
- ΔR Range Increment of Aircraft (Kilometer)
- η Propeller Efficiency
- η_r Rotor Efficiency
- μ_{friction} Coefficient of Friction
- ξ Coefficient of Power loss



Constants, Functions, Measurements used

- **Function: $\ln$, $\ln(\text{Number})$**
The natural logarithm, also known as the logarithm to the base e , is the inverse function of the natural exponential function.
- **Function: $\log_{10}$, $\log_{10}(\text{Number})$**
The common logarithm, also known as the base-10 logarithm or the decimal logarithm, is a mathematical function that is the inverse of the exponential function.
- **Measurement: Length** in Kilometer (km)
Length Unit Conversion 
- **Measurement: Weight** in Kilogram (kg)
Weight Unit Conversion 
- **Measurement: Time** in Second (s)
Time Unit Conversion 
- **Measurement: Area** in Square Meter (m^2)
Area Unit Conversion 
- **Measurement: Speed** in Knot (kn)
Speed Unit Conversion 
- **Measurement: Force** in Newton (N)
Force Unit Conversion 
- **Measurement: Specific Fuel Consumption** in Kilogram per Hour per Watt (kg/h/W)
Specific Fuel Consumption Unit Conversion 



Check other formula lists

- Preliminary Design Formulas 

Feel free to SHARE this document with your friends!

PDF Available in

[English](#) [Spanish](#) [French](#) [German](#) [Russian](#) [Italian](#) [Portuguese](#) [Polish](#) [Dutch](#)

5/9/2024 | 6:19:19 AM UTC

[Please leave your feedback here...](#)

